Summary of the 2018 Sun-Climate Symposium

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Introduction

The 2018 Sun-Climate Symposium was held at the University of California, Los Angeles (UCLA) Conference Center in Lake Arrowhead, CA, March 19-23, 2018. The Sun-Climate Research Center—established as a collaboration between NASA's Goddard Space Flight Center (GSFC) and the Laboratory for Atmospheric and Space Physics at the University of Colorado (LASP/CU)—organized this gathering of experts from the solar-terrestrial community and various sun-climate disciplines. The timely theme of the symposium was *The State of the TSI and SSI Climate Records at the Junction of the SORCE & TSIS Missions.*[1] There were six oral sessions that covered solar and climate observations, models, solar variability, and expectations for the next solar cycle, in addition to two poster sessions spanning these same topics. Over 80 scientists and students from around the world gathered to present their findings and to engage in spirited discussions. Most of the 2018 Sun-Climate Symposium presentations are available online at *http://tinyurl.com/y7jku7zu.*

Attendees at the 2018 Sun-Climate Symposium in Lake Arrowhead, CA. **Photo credit**: Vanessa George [LASP/CU]

Meeting Overview

This meeting occurred during an important juncture in the measurement record of solar irradiance. The Solar Radiation and Climate Experiment (SORCE) recently celebrated the 15-year anniversary of its launch, a feat that was celebrated at the symposium—see photo below. SORCE not only ushered in advanced capabilities for measuring total and spectral solar irradiance—accompanied by a large number of science achievements—it has lasted for 10 years beyond its scheduled mission lifetime. In so doing, SORCE has helped preserve the existing 40-year space-based solar-irradiance data record—see **Figure** below.

[1] The acronyms in the title of the symposium are defined in the text that follows.

Celebration cake for SORCE's fifteenth birthday. **Photo credit**: Vanessa George [LASP/CU]

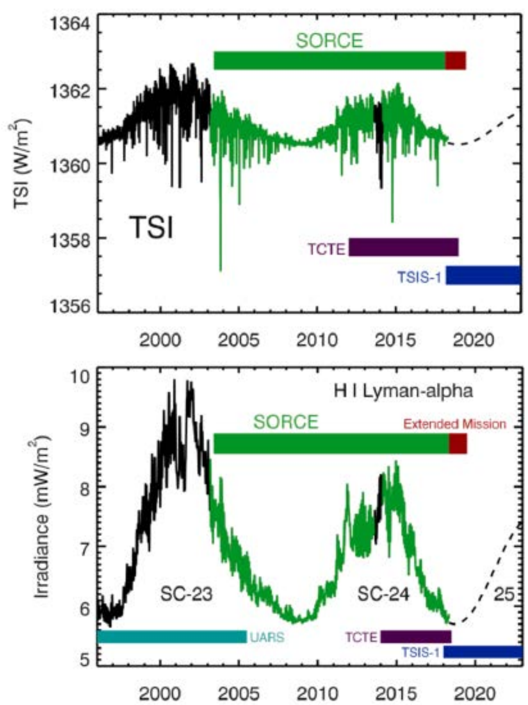

Figure. The solar observations over the Solar Radiation and Climate Experiment (SORCE) mission, shown for total solar irradiance (TSI) [*top*] and the ultraviolet H I Lyman-alpha [*bottom*], include solar cycles 23 and 24, and an extended mission that will include the start of cycle 25. The higher-frequency variations, such as the large dips in the TSI, are caused by the presence of solar active regions rotating with a period of ~27 days. The larger 11-year solar cycle variation is a key forcing function in Earth's atmosphere and climate. **Image credit**: Tom Woods [LASP/CU]

During the meeting the "baton" for total solar irradiance (TSI) and solar spectral irradiance (SSI) monitoring was officially passed from SORCE to the Total and Spectral Solar Irradiance Sensor (TSIS-1), though SORCE intends to keep on going for at least a year of overlap with TSIS-1 in order to understand potential offsets between the two sets of sensors. **Photo credit:** Peter Pilewskie [LASP/CU]

As SORCE winds down, the Total and Spectral Solar Irradiance Sensor-1 (TSIS-1) is just beginning its mission. TSIS-1 was launched to the International Space Station (ISS) on December 15, 2017. The SORCE-heritage Total Irradiance Monitor (TIM) and Spectral Irradiance Monitor (SIM) on TSIS-1 have both experienced first light.[2] Preliminary data from the TIM and SIM instruments on TSIS-1 (referred to henceforth as TSIS TIM and TSIS SIM) were presented at the symposium.

Opening Remarks

Peter Pilewskie and **Tom Woods** [both from LASP/CU—*TSIS-1* and *SORCE Principal Investigators,* respectively] provided opening remarks to put the unique timing of this year's symposium into perspective. Measurements of solar irradiance from space began four decades ago with the launch of the Nimbus 7 satellite that carried the Earth Radiation Budget (ERB) and Solar Backscatter Ultraviolet (SBUV) sensors.[3] Remarkable progress has been made since that time in our ability to monitor ever smaller changes in the sun's output, integrated over the entire spectrum and in individual wavelength bands, and with increased radiometric accuracy. This has improved our understanding of the sun's influence on past and present climate, enhanced our ability to predict future climate, and helped us gain insight into the mechanisms by which the Earth system responds to subtle variations in solar irradiance.

During their remarks, Pilewskie and Woods symbolized the linkage between SORCE and TSIS using a relay baton that was physically passed from the SORCE PI to the TSIS PI: i.e., from one measurement program to the next to continue the four-decades-long solar-irradiance climate data record—see graphic above. We are currently in a one-year overlap period between the SORCE, the Total Solar Irradiance Calibration Transfer Experiment (TCTE),[4] and the TSIS-1 missions.

[2] To view these images and learn more, see the front cover image and the Editorial of the March–April 2018 issue of *The Earth Observer* [**Volume 30**, **Issue 2**, pp.1-3—*https://eospso.gsfc.nasa.gov/sites/default/files/eo_pdfs/Mar_Apr_2018_color%20508_0.pdf*].

[3] To learn more about the Nimbus series and its instruments, see "Nimbus Celebrates 50 Years" in the March–April 2015 issue of *The Earth Observer* [**Volume 27**, **Issue 2**, pp. 18-31—*https://eospso.nasa.gov/sites/default/files/eo_pdfs/Mar_Apr_2015_color_508.pdf*].

[4] TCTE is a payload onboard the U.S. Air Force Space Test Program spacecraft known as STPSat-3, which launched in November 2013.

SORCE still has a firm grasp on the baton that it has ever so gently laid in the hand of TSIS-1. It won't release that responsibility for several months until after completion of the overlap.

Session 1: The Creation, Significance, and Applications of Accurate Climate Data Records

The symposium kicked off with a session on climate data records (CDRs). The National Research Council (NRC) defines a CDR as "a time series of measurements of sufficient length, consistency, and continuity to determine climate variability and change." Given the nature of this climate-themed symposium it was fitting to have a session that considered: *How are CDRs made, what scientific understanding is gained from them, and what challenges exist for future climate measurement systems and models to produce CDRs?* Presentations during this session answered these and other questions related to CDRs.

Bruce Wielicki [NASA's Langley Research Center] gave the featured keynote presentation for this session, *Designing the Climate Observing System of the Future*. In it he contrasted the attributes of climate versus weather observations, the distinction being primarily one of accuracy. Maintaining accuracy over decadal time scales is such a challenge that at the present time there is no cohesive global climate-observing system to obtain the 50 or so essential climate variables needed to even adequately describe the state of Earth's system. Although the costs of establishing such an observing system would require a tripling of what the world currently invests in climate observations, quantitative economic analyses suggest that even the most conservatively estimated returns on that investment will be a factor of several tens or more—considerably more than from other societal investments. Wielicki provided guidelines outlining the need, value, and methods for designing such a future climate observing system, while suggesting that scientists must better articulate to the public the size of the investment required and the tremendous return on that investment that will be realized.

John Bates [John Bates Consulting, Inc.] provided a historical perspective of the NOAA Climate Data Records Program that has now transitioned more than 41 CDRs into initial operating capability. He outlined the evolution from research to initial and then full operational status through the use of a maturity-assessment approach. Bates stressed that an independent CDR maturity assessment should be mandatory and required for any dataset used to help set policy.

A broad range of CDRs was discussed in this session, including the three-decade-long record of sea ice concentration data from passive microwave remote sensing, as were improvements to surface-based aerosol remote sensing from higher-accuracy solar-irradiance spectra. In keeping with the sun-climate theme, other talks covered the incorporation of data from the SORCE TIM for constraining Earth's energy budget, the benefit of CDRs, efforts to ensure the continuity of long-term observations of solar activity, and the use of Helioseismic Magnetic Imager (HMI)[5] data to estimate facular[6] and network contributions to solar irradiance.

Session 2: The State of the TSI and SSI Climate Records Near the End of the SORCE Mission

The focus of this session was on the total solar irradiance (TSI) and solar spectral irradiance (SSI) records since the start of the space era, with emphasis on how measurements of the last decade have been reconciled with and contributed to composite records and their associated time-dependent uncertainties.

Numerous presentations in this session showed TSI measurements from different instruments and missions. Among the highlights were the 21-year record of TSI from VIRGO on SOHO, Version 2 of PREMOS on PICARD, and first-light observations from CLARA on NorSat.[7] The TIM, first deployed—and still flying—on the SORCE mission, now has two companions in orbit, a SORCE-era TIM on TCTE and the newest version of TIM that is part of TSIS-1. Participants got to see the TIM intracomparisons and the intercomparisons of all of these contemporaneous TSI instruments.

SSI measurements from the Sun Monitoring on the External Payload Facility of Columbus-SOLar SPECtral Irradiance Measurements (Solar-SOLSPEC) instrument that flew on the International Space Station for almost nine years have been reanalyzed resulting in a new absolute reference spectrum. These data, like those from the SIM instruments on SORCE and TSIS, cover well over 90% of the TSI. First-light measurements from the TSIS SIM (mentioned previously) were presented during this session. The TSIS SIM is off to a good start: its integrated irradiance matches the TIM total irradiance to within the SIM uncertainty of 0.2%.

Other measurements of SSI isolate the ultraviolet regions of the spectrum, where much of the photochemical reactions in Earth's atmosphere occur. For example, the Ozone Monitoring Instrument (OMI) on Aura has a primary mission of measuring atmospheric trace gases, which requires that it acquire SSI data over the 265-500-nm spectral range. The combination of high stability of OMI (in operation since 2004) and a newly revised degradation model has resulted in a high-quality SSI record spanning the entirety of solar cycle 24 (SC24), with the ability to resolve solar variability to better than 0.1%. The OMI SSI dataset was shown during this session. Separating instrument degradation from solar variability remains one of the greatest challenges in developing climate-quality measurement records of solar irradiance. Accordingly, some presentations during this session detailed advanced techniques for deriving instrumental trends and their effects on the data.

Understanding solar influences on the terrestrial environment requires high-fidelity, long-term records of solar irradiance. While improved instrument accuracy and stability and the ability to track instrument degradation is crucial, creating composite records also requires keeping close watch on how overlapping records are merged. Some new methods for creating data composites are not only improving the accuracy of long-term TSI and SSI records, but they now provide time-dependent quantified estimates of uncertainties, an important but often missing attribute that is required for most applications. This session detailed some of these new state-of-the-art approaches for creating TSI and SSI composites. For example, **Thierry Dudok de Wit** [Laboratoire de Physique et Chimie de l'Environnement et de l'Espace, University of Orléans, France] presented a probabilistic and statistically driven approach for creating a TSI composite that relies on weighted contributions from all available datasets at any one time. Participants also learned about improvements in the Spectral and Total Irradiance Reconstruction (SATIRE) and Naval Research Laboratory's solar irradiance models (NRLTSI and NRLSSI) that are used to reconstruct solar irradiance all the way back to the start of sunspot records in the early seventeenth century.

During the session, **Jerry Harder** [LASP/CU] provided some brief remarks commemorating the loss of **Juan Fontenla** [formerly of LASP/CU] in January 2018—see *Remembering Juan Fontenla* on page 24.

Session 3: Next Generation of Solar and Atmospheric Observations

The driving question for this session was: *What new missions, sensors, and implementation strategies will be required for a next-generation observing system to meet the current and future challenges facing climate change studies?* Solar and climate observations are the critical foundations for understanding the current and future of the Earth system, yet the current observing system is inadequate to answer some fundamental questions related to variability over seasonal and longer time scales.

[5] HMI is an instrument that flies on NASA's Solar Dynamics Observatory.

[6] Faculae are dark regions on the sun's surface.

[7] VIRGO stands for the Variability of Solar Irradiance and Gravity Oscillations, which is an instrument on NASA's Solar and Heliospheric Observatory (SOHO); PREMOS stands for Precision Monitoring Sensor, which is an instrument that flew on the French PICARD mission; and CLARA stands for Compact Lightweight Absolute Radiometer, which flies on the recently launched Norwegian NorSat-1 satellite. (**Note**: PICARD is not an acronym; it was named after seventeenth-century French astronomer Jean Picard.)

Remembering Juan Fontenla [*1948–2018*]

Juan Fontenla passed away on January 11, 2018, at his home in Simpsonville, SC. Juan made numerous contributions to the study of the sun and stars during his 37-year career. He is perhaps best known for developing the Solar Radiation Physical Model (SRPM) that he applied to the study of solar spectral irradiance variability for NASA's SORCE mission. As a member of the SORCE science team, Juan was instrumental in the analysis and interpretation of SORCE SIM data. Juan leaves behind his wife and two sons.

Photo credit: Vanessa George [LASP/CU]

Elizabeth Weatherhead [CU, Cooperative Institute for Research in Environmental Sciences (CIRES)] presented a framework for prioritizing observations that address three different objectives: trend detection, short-term process studies, and seasonal forecasting. She stressed that prioritizing the needed observations should not be limited by current technologies, but they should be rigorously and independently evaluated to assure that the observing system is sufficient for the proposed goals.

There is reason to be optimistic that next-generation missions will improve our climate-observing capabilities. For example, the NASA Plankton, Aerosol, Cloud, ocean Ecosystem (PACE) mission, scheduled for launch in 2022, will extend key heritage ocean color, cloud, and aerosol data records, while providing new insight into oceanographic and atmospheric responses to Earth's changing climate. PACE will fly a spectroradiometer and two polarimeters that will revolutionize studies of global biogeochemistry, carbon cycles, and aerosols in the ocean-atmosphere system.[8]

New small and highly capable instruments are in the planning stages for future solar- and Earth-viewing observations of the global energy budget. The Compact Spectral Irradiance Monitor (CSIM) and the Compact Total Irradiance Monitor (CTIM) employ vertically aligned carbon nanotube (VACNT) bolometers to meet climate-quality requirements of solar irradiance but with reduced mass, volume, and power consumption compared to their predecessors—the TIM and SIM instruments currently flying on SORCE and TSIS-1. CSIM is scheduled for launch in late 2018, while the CTIM will be built and environmentally qualified in 2018-2019 in preparation for a future flight opportunity.

Another experiment is the Radiometer Assessment using Vertically Aligned Nanotubes (RAVAN) 3U CubeSat, which was launched in November 2016 and is still operating. RAVEN is a pathfinder for a future constellation implementation to measure the Earth's radiative energy imbalance. The Swiss Physical Meteorological Observatory (PMOD)/World Radiation Center (WRC) in Davos has developed the highly versatile Davos Digital Absolute RAdiometer (DARA) to measure TSI on diverse missions like the ship-tracking microsatellite on the Norwegian NorSat-1 mission, the Chinese FengYun-3 (FY-3E) meteorological observatory, and the European Space Agency's PROBA-3[9] solar occultation mission. Modified versions of the DARA instrument have been proposed to measure Earth's radiation imbalance in future missions, similar to the RAVEN concept.

After Session 3 there was an optional excursion to Big Bear Solar Observatory to see the world's highest-resolution solar telescope—see *A Trip to Big Bear Solar Observatory* on page 25.

Session 4: Impacts of Solar Variability on the Terrestrial Environment during Solar Cycle 24

This session addressed the following questions relevant to solar variability's impacts on Earth's environment:

- *With SC24 being one of the weakest during the past 90 years, can we reliably discern the terrestrial signatures of the current solar inactivity—at the surface, in the stratosphere, and in space weather?*
- *It has been established that the upper-atmosphere density has had a long-term decrease from cooling above 300 km (~186 mi) by greenhouse gases and due to the reduced solar activity in SC24. Are there*

[8] To learn more about PACE, see "NASA sets the PACE for Advanced Studies of Earth's Changing Climate" in the July–August 2015 issue of *The Earth Observer*, [**Volume 27**, **Issue 4**, pp. 4-12—*https://pace.gsfc.nasa.gov/docs/earth_observer_jul_aug_2015.pdf*].

[9] PROBA-3 is the third in the European Space Agency's series of PROBA low-cost satellites that are being used to validate new technologies for spacecraft, while also carrying a scientific payload.

similar indications in the lower atmosphere for warming due to greenhouse gases and other changes due to reduced solar activity?

- *What does understanding of the present (in the context of the past) infer for the future variability of Earth's environment?*

Lesley Gray [University of Oxford] delivered a keynote address centered on these themes. She highlighted the 11-year variability in weather patterns over Europe that is driven by the North Atlantic Oscillation (NAO). As is often the case in correlating weather and climate signals with the solar cycle, the signal appears to be present in some periods but not others, suggesting that it may be a random artifact. Using data going back to 1660, Gray showed evidence of an 11-year signal in weather patterns but with a response that varied in strength and phase with an 11-year solar-forcing cycle. She proposed that a coupled atmosphere–ocean mechanism could explain a lag in response of three to four years. The resultant observed signal would depend on the strength of this mechanism in addition to solar ultraviolet forcing of stratospheric temperatures and wind and subsequent response at the surface.

The session was as diverse as its description suggested. Solar-cycle induced variability in middle atmosphere carbon monoxide and nitrogen dioxide levels, cloud cover over the poles, Arctic ozone, El Niño and La Niña

A Trip to Big Bear Solar Observatory

On the afternoon of the third day of the symposium, attendees had the opportunity to visit Big Bear Solar Observatory (BBSO). BBSO is operated by the New Jersey Institute of Technology (NJIT), with funding from the National Science Foundation, NASA, the U.S. Air Force, the Korean National Science Foundation, and other government and private sources. It is home to the world's highest-resolution solar telescope, recently renamed the Goode Solar Telescope (GST) after former director Phil Goode [NJIT] who was instrumental in its design, construction, and realization. Current Director **Wenda Cao** [NJIT] gave a short presentation at the symposium on the history, achievements, and capabilities of BBSO.

Some of the Sun–Climate Symposium participants enjoyed an afternoon trip to nearby Big Bear Solar Observatory to see the world's highest-resolution solar telescope. **Photo credit:** Tom Woods [LASP/CU]

The 1.6-m (~5-ft) clear-aperture, off-axis GST was the first facility-class* solar telescope built in the U.S. in a generation. Benefitting from the long periods of excellent seeing conditions at Big Bear Lake, the GST can produce simultaneous images of massive explosions such as solar flares and coronal mass ejections that occur at approximately the same time across structures as large as a 20,000 mile-wide sunspot in the sun's photosphere. Since beginning regular operation in 2010, it has provided the community with open access to observations of the solar photosphere, chromosphere, and up to the base of the solar corona with unprecedented resolution, targeting the fundamental nature of solar activity and the origin of space weather. There are two other facilities at BBSO, housing an "earthshine" telescope and a Global Oscillation Network Group (GONG)** telescope.

*A *facility-class instrument* is one designed as a standard instrument for community use. This distinguishes it from a *principal investigator (PI) instrument*, which is custom-designed for use by an individual investigator. Researchers can simply specify what measurements they want from a facility instrument, and the on-site operator can acquire the data and send it to the remote investigator.

**GONG is a community-based program to conduct a detailed study of solar internal structure and dynamics using helioseismology. Learn more at *https://gong.nso.edu*.

patterns, and the East Asian Monsoon were addressed. New results from Coupled Model Intercomparison Project Phase 5 (CMIP-5) provided evidence that the response of climate models to solar variability has improved, with subsequent impacts on the attribution of observed recent surface temperature variability. There was also discussion about longer-term solar variability—consistent with the Centennial Gleissberg Cycle (CGC)[10]—which has a climate response that is distinctly different from other sources of climate forcing.

Session 5: Stellar Variability and Connections to the Sun

Presentations given during this session addressed the following specific questions on stellar variability as it relates to the sun.

- *How typical is the cyclic activity of our sun relative to sun-like stars?*
- *What have we learned from NASA's Kepler Mission[11] and ground-based synoptic programs about the ranges of total and spectral irradiance variability?*
- *What progress have we made in understanding what controls the amplitude and length of cyclic activity in a sun-like star?*

Jeffrey Hall [Lowell Observatory] delivered the keynote presentation on the variability of sun-like stars. He reported that we now have a reasonably comprehensive picture of solar variability in the stellar context. Significant progress has been made in cross-calibration between datasets from the Lowell Observatory Solar-Stellar Spectrograph project and Mount Wilson Observatory HK Project. He provided evidence of what could be the first confirmation of a sun-like star in a Maunder Minimum transition.

Other presentations during this session revealed several of the advances made in understanding our sun through the behavior of sun-like stars. For example, the sun's rotation rate and magnetic field are currently in a transitional phase typical of middle-aged stars—the solar cycle is currently growing longer on stellar evolutionary time scales that will end with the shutdown of the global dynamo sometime in the next 0.8–2.4 Gyr.

This leads to the question: *How typical is the sun as a variable star?* A longstanding puzzle that solar brightness variability over the 11-year activity cycle is anomalously low compared to that of sun-like stars with similar levels of magnetic activity was explained on the basis of small differences of stellar metallicity. Another way to map what is observed from stellar brightness variability onto solar variability is to imagine how the sun's brightness would vary if observed from Kepler, that is, out of the ecliptic. This helps determine how our concepts of solar brightness variability have to be altered to reproduce the distribution of observed variability in Sun-like stars.

Exoplanets were another topic of discussion in this session. Magnetic activity and flares from exoplanet type-M dwarf host stars were reviewed because they are often targets for habitable-zone planet searches. There is still much that is unknown about type-M dwarf flare spectra in the near-ultraviolet between 200-350 nm, an important wavelength range for planetary surface biology and ozone chemistry in habitable-zone planets. Climate and habitability of Earth-like exoplanets was also the focus of another presentation. Since we now have evidence from Kepler that extrasolar planets are quite common, the next steps are to confirm the existence of habitable, or even inhabited extrasolar planets. Future observations from the James Webb Space Telescope and the next generation of 30-m ground-based telescopes will begin observing these worlds.

Session 6: What Are the Expectations for the Next Solar Minimum and Solar Cycle 25?

The presentations in this session addressed the following questions related to predicting how the next solar cycle will behave:

- *Are spectral and total solar irradiance levels lower now than during past minima? How much will they change during SC25?*
- *Are we entering a new prolonged period of anomalously low activity such as the Dalton Minimum in the early 1800s?*
- *Can we identify anomalous behavior in the solar dynamo and surface magnetic flux transport as we enter this next cycle minimum? Do they provide insight into the activity level of the next cycle?*

Scott McIntosh [National Center for Atmospheric Research/High Altitude Observatory] gave the keynote presentation for this session, during which he provided a fascinating picture of solar variability and its predictability based on the 22-year solar magnetic cycle. Tracking the evolution of small-scale magnetic features in the solar corona can explain the behavior of present, current—and potentially future—sunspot cycles. Contemporary observations of the solar corona reveal long-lived patterns that mark the 22-year solar magnetic activity cycle. The modulation of these patterns can explain the landmarks of the sunspot cycle that occur over about half of the magnetic cycle span.

[10] The CGC is a 90–100 year cycle in the sunspot number, geomagnetic activity, occurrence of midlatitude auroras, and large fluence Solar Energetic Particle events.

[11] This mission is specifically designed to survey our region of the Milky Way galaxy to discover hundreds of Earth-size and smaller planets in or near the habitable zone and determine the fraction of the hundreds of billions of stars in our galaxy that might have such planets.

These features suggest that solar minimum for SC24 is almost at hand, that SC25's sunspots will begin to appear in late 2019 to early 2020, and that SC25 will be weaker than SC24. It should be noted that **Leif Svalgaard** [Stanford University] posited the opposite—i.e., that SC25 would be larger than SC24. This prediction is based on the magnitude of the sun's polar fields as derived from the solar axial dipole moment.

Others in this session discussed the underlying mechanisms of solar variability. Several *dynamo theories*—which are the basis for many prediction schemes—were reviewed and critically examined over solar-cycle-to-much-longer, climate-relevant time scales. *Helioseismology*, an important tool for detecting plasma motion deep inside the sun, has revealed that the internal flows are generally more complex than is assumed by dynamo theories. Finally, there was discussion of morphology and evolution of faculae and comparisons of galactic cosmic-ray intensities with estimates from cosmogenic isotopes.

Conclusion

NASA's Earth Science missions, including the SORCE and TSIS-1 missions, are critical for advancing our understanding of the complexity of Earth's systems and their connection to the encompassing solar environment; new climate missions are required to continue these valuable climate records. The 2018 Sun-Climate Symposium emphasized the connections between solar variability and Earth's climate at an important juncture in the measurement record during overlap of the SORCE and TSIS-1 missions. Moreover, we are also approaching a minimum in the sun's activity cycle; how the sun will vary over the next cycle and the Earth system response are intense areas of study. The Sun-Climate Symposium addressed these issues in the context of present-day climate change and anthropogenic and natural drivers. The multidisciplinary nature of the meeting brought together specialists in measuring and modeling the sun's output and Earth's radiation budget, climate and atmospheric modelers who interpret those and other forcings and quantify Earth's changing environment, solar physicists who study how the sun varies, and other specialists developing new instruments and missions to address some of the questions that were addressed in the meeting. The meeting participants look forward to the next symposium, when updates on some of the most vexing issues in Sun-Earth connections will be discussed, as new questions are sure to arise.

To stay up to date on the latest TSIS and SORCE news and meeting announcements, read the TSIS/SORCE newsletter at *http://lasp.colorado.edu/home/sorce/news-events/newsletter*. ■

KUDOS: Claire Parkinson Elected 2018 Academy Fellow

Claire Parkinson [NASA's Goddard Space Flight Center—*Aqua Project Scientist*] has been elected a Fellow of the American Academy of Arts and Sciences—one of 177 elected in 2018.

As one of the country's oldest learned societies and independent policy research centers, the Academy convenes leaders from the academic, business, and government sectors to respond to the challenges facing the nation and the world. Others elected this year include, most prominently, former President Barack Obama and actor Tom Hanks. The complete list of Academy Fellows (177) and International Honorary Members (36) elected in 2018 can be viewed at *https://www.amacad.org/content/members/newFellows.aspx?s=c*.

The Earth Observer congratulates Parkinson on this prestigious honor!